Aspects to develop a R2R coater

Johannes Krantz, J. Hoffmann, M. Klosch-Trageser, G. Löbig, P. Sauer
Schmid Vacuum Technology GmbH Karlstein Germany

Extended Abstract

R2R (Roll to Roll) systems for packaging films are built since the early 1950's. The need of R2R metallizers for flexible packaging has increased continuous with need for food packaging. The packaging industry claimed over the years, always thinner and less expensive packages together with stronger requirements for the barrier properties to extend the shelf life of foods.

While initially PET (polyethylene terephthalate) films, with a thickness of 20 microns to 30 microns, are coated with a thick layer of aluminum, are today different types of film such as PET, OPP, BOPP, CPP, etc., thickness by 6 microns to 20 microns, coated with different barrier layers like aluminum or aluminum oxide . Initially used film widths were between 0.6 m to 1.2 m.

While the film producers are becoming more widespread film inserting lines to increase the throughput and the film bales were cut in width, had to build the conveyor system manufacturers are faster systems. After the initial investments 6 m / sec speed film were coated in 90 like the plants was 12 - 14 m / sec Now the plants had to be wider from Originally 0.6 m width to 3 m coating width.

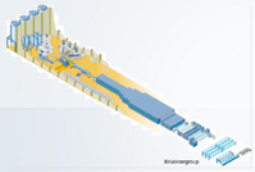
The broadest plant at present is 4450 mm which is half the width of a role currently maximum extrudable raw film of about 9000 mm wide. These changing conditions force the plant engineers to more recent concepts and developments at the same time to be cheaper.

The presentation describes the process, analysis and drafting equipment to construct a new design based on market requirements, with the help of existing technology and the necessary "Know How" to the latest generation of packaging conveyor systems for the food packaging market.

It illustrates the decision-making during the redesign of the system components for which are always the development steps of the latter generations used for comparison. Added to the current customer requirements for optimization with tiles in the concept

The current requirements for width, flexibility, vacuum system, coating sources, plant operation, role handling, quality control, service and ease of repair are discussed and quantified. A final summary presents the results.

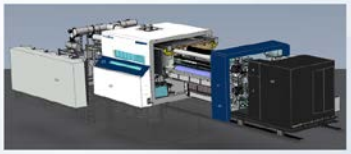
Substrate Parameter, to be considered



- Coating width: 1450 mm – 2850 mm
  - Fit to film lines width of 8,4 m to 10,4 m
- The maximum coating width grew over the years due to the increasing Film-line sizes
- Maximum Roll diameter 1250 mm
- The used roll diameter, depends on:
  - the process conditions (layer)
  - run time of the coating source

Further Parameter, to be considered

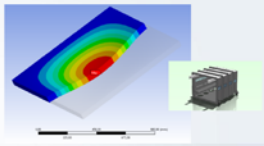
- Material line speed: Up to 20 m/sec, →high throughput
- Footprint is driven by:
  - substrate sizes
  - subsystems
- Energy efficiency
- Media consumption
- Investment
- Substrate range:
  - type
  - thicknesses



TetraDisc

Chamber requirements

- Design Questions
- Volume →Vacuum -> Winding Path Static no bending
- Material? Plastic, SST, Al casted, painted?
- How many view ports do I need, and where?
- How is the access to Evaporator => two operator for fast boat change
- Flexibility, expandable for several width?
- Servicing and maintenance can be performed
- Are there known proven solutions like ...
- And what can be optimized?



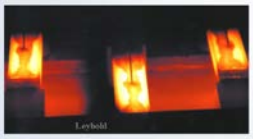
The chart shows the bowing under load of a 1 m x 1 m x 50 mm plate, the bar diagram shows how much

Vacuum system

- Pump down time
- Pumping capacity
- Ultimate pressure
- Venting time
- Footprint
- Flexibility
- Energy consumption
- Noise level
- Maintenance friendly
- Cold trap surface
- Additional pump set
- Pump down time over the years

1985	1990	2000	2010
20 min	13 min	6 min	< 6 min

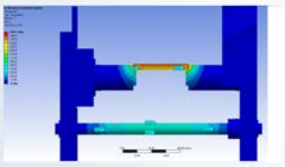
Sources

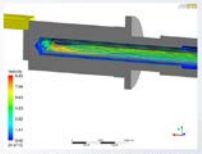


- **Boat evaporator for:**
  - Al thick (barrier) 1.5 OD – 4 OD
  - Al thin (anti static) app.0.5 OD
  - Transparent barrier coating AlOx Ts ~ 90%
- **Coating material:**
  - Al wire size 1.5 mm – 2.0 mm
  - Aluminum coil diameter 280 mm - 360 mm
- **The target is:**
  - High collection efficiency
  - Excellent distribution
  - No splashes, pinholes
  - Long boat live time
  - Less wall deposition
  - Fast maintenance, clean ability
- **We need:**
  - Precise al wire feed
  - Staggered boat arrangement
  - Energy-efficient operation using intelligent system control

Sources

The design starts with the contact bold





For the bold cooling the software simulation shows the fluid velocity and the resulting temperature distribution

- A software simulation is used showing the temperature distribution in the contact bold at working point for one boat
- Advanced software tools and it right use enables a further optimization of proved components

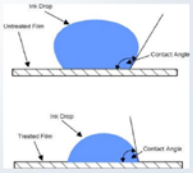
Pre treatment

The pre treatment following on the web pass the unwinder is needed! To improve adhesion by strengthen the surface tension.

Via a low-pressure plasma adapting to the coating speed and film type. This results in better barrier properties.

Examples of surface tension:

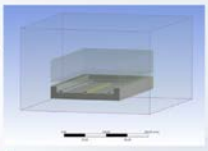
	Untreaded	treaded
BOPP	38 dyn	44 dyn
PET	42 dyn	44 dyn

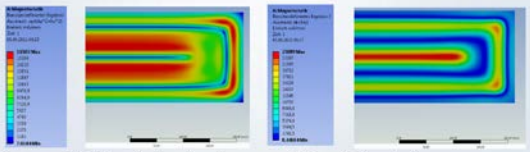


Source Brigham Young University

Pre / Post treatment

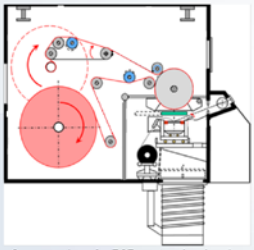
The needed low pressure plasma source has to fit to the treatment need of different foils BOPP or PET as well as to the maximum winding speed of the coater.
Power and gas flow needs to be adaptable to optimize the surface tension.
Typical used are planar magnet enhanced cathodes where the power type varies from DC, pulsed DC, MF or RF





The magnetic field strength shows the plasma concentration on the target surface versus different magnet file strength, the plasma width can be easily optimized.

Winding

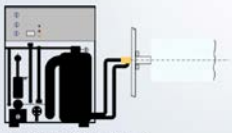


Cross section of a R2R coater showing the winding system.

- **Design requirements:**
  - Use of standard components and parts
  - Easy access to the roller
  - Easy roll exchange
  - Easy roll cleaning
  - Robust
  - Minimum needed number of roller
- **Roller functions:**
  - Winding shafts
  - Guiding roller
  - Spreading roller
  - Coating drum
  - Measuring roller
  - Tension roller
  - Post cool roller
- **Requirements are:**
  - Light weight
  - Excellent concentricity

Winding

Von Ardenne Coating Drum



Sketch of a chiller coating drum connection

The coating drum is the most important roll of the winding system here we have to look at

- Bearings / feed trough
- Diameter
- Roll weight
- Tube design -> inertia of masses in movement
- Surface performance
- Defect avoidance (scratches, pin holes, pin windows)
- Homogen temperature distribution -15 °C to 35°C +/- 2°C

Intelligent winding control via PLC for

- Precise web tension control 70 N to 700N

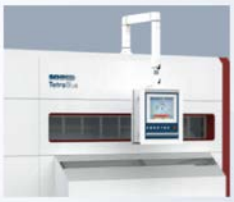
Operation Requirements

HMI interface

- Easy
- Safe
- Operator friendly
- Maintenance friendly
- Self explaining user interface
- Clearly arranged

Full Automatic two button system

- Sequence:
  - Pump down
  - Evaporator on
  - Al wire start
  - Winding start
  - Shutter open
  - Layer control on
  - Stop at roll end
  - Venting



Further requirements

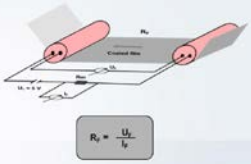
- Machine control
- Error management
- Winding control
- Safety interlocks
- Reliable

Quality control

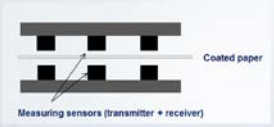
Electrical:

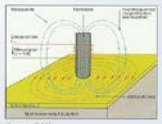
Roll to Roll sheet resistance measurement can be used for closed loop layer thickness control in web direction.

Eddy currant sheet resistance measurement can be used for closed loop thickness control in web direction and transversal thickness control.



$$R_{\square} = \frac{U_E}{I_P}$$





Source BAM

SUMMARY

- To get the latest state of a R2R coater we have to consider the interaction of all components
- The use of Computer Aided Engineering (CAE) enables the optimization of known used components
- By choosing the latest development of components combined with field proven components resulting in high quality design
- State of the art packaging roll to roll coater need to have insitu quality control

Quality control

Optical density measurement is used for quality monitoring via a roll report as well as for a closed loop thickness control for each single evaporator boat.

This results in good layer distribution.

The measuring wavelength is typical 860 nm